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A5R RFA R24 R25B2 R25C
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None

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(54) **Damper cylinder for artificial leg**

(57) An artificial leg for a person having no knee joint, includes a cylinder (4) disposed between upper and lower members (1, 2) (Fig 1) of the leg, the members being coupled through a pivotable joint (3). The cylinder controls bending of the leg, and has an air cushion for convenience of walking. The cylinder includes a cylindrical sleeve (10) closed at both ends and a piston (16) having a piston rod (18) slidable in the sleeve. One of two inner chambers (24, 26) separated by the piston acts as an air cushion, thereby absorbing the shock between the upper and lower members (1, 2) at the end of stretching the leg. To do this, the rod cover (14) has a cylindrical cavity (38) to receive a major diameter portion (36) of the piston rod (18), a channel (44) with an adjustable throttle (45) connecting the cavity (38) with the rod chamber (26). A computer controlled motor (33) adjusts the needle valve (32) of a throttle (30) in a path (29) through the piston, e.g. in accordance with walking speed.

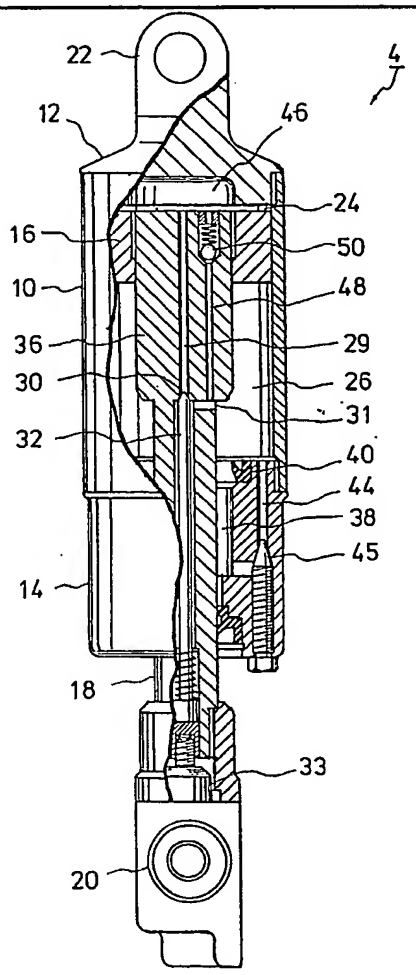

FIG. 5

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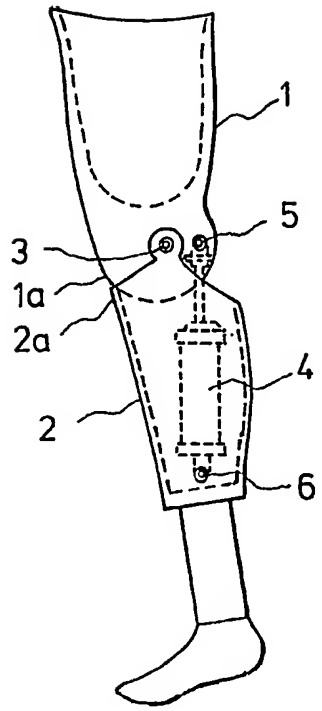
1
5
3
1a
2a
4
2
6

FIG. 1

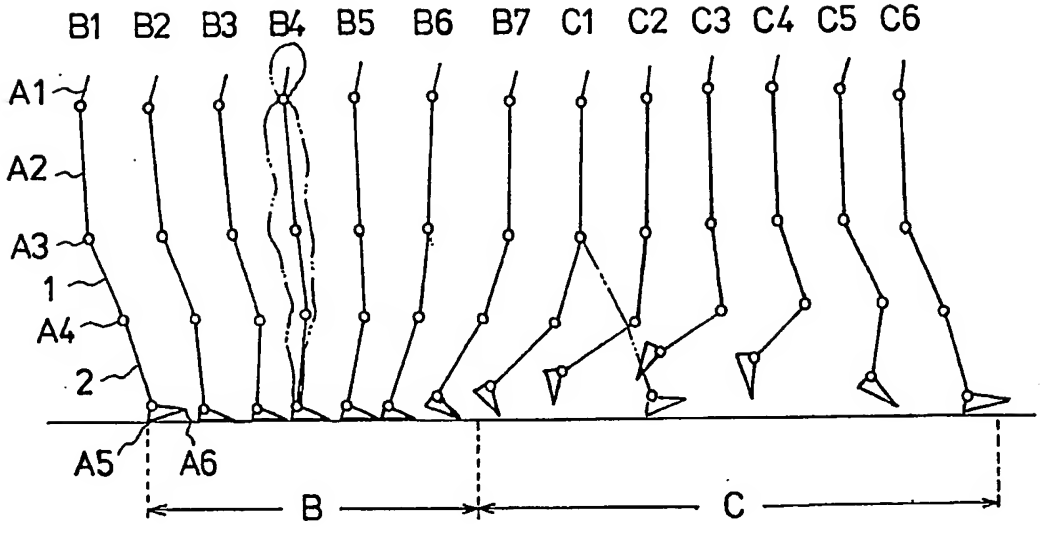
B1
B2
B3
B4
B5
B6
B7
C1
C2
C3
C4
C5
C6
A1
A2
A3
1
A4
2
A5
A6
B
C

FIG. 4

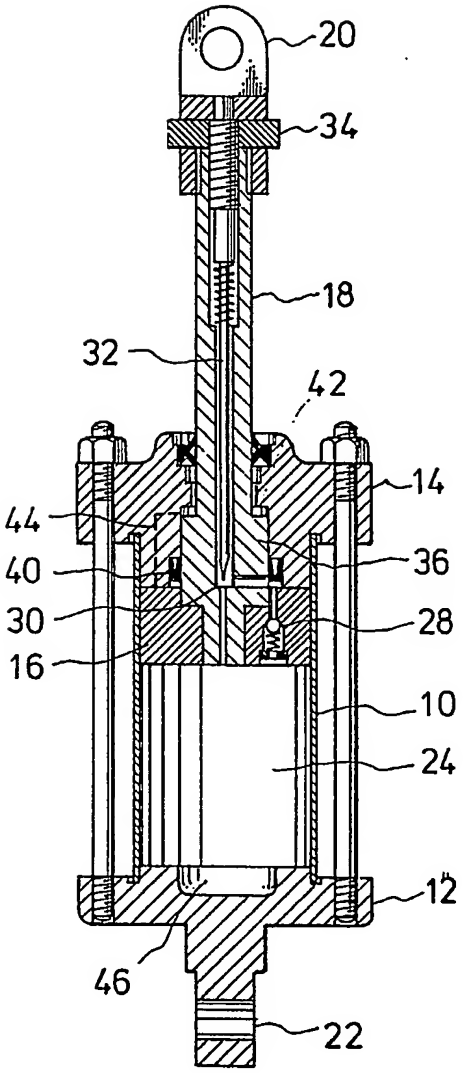

FIG. 2 (PRIOR ART)

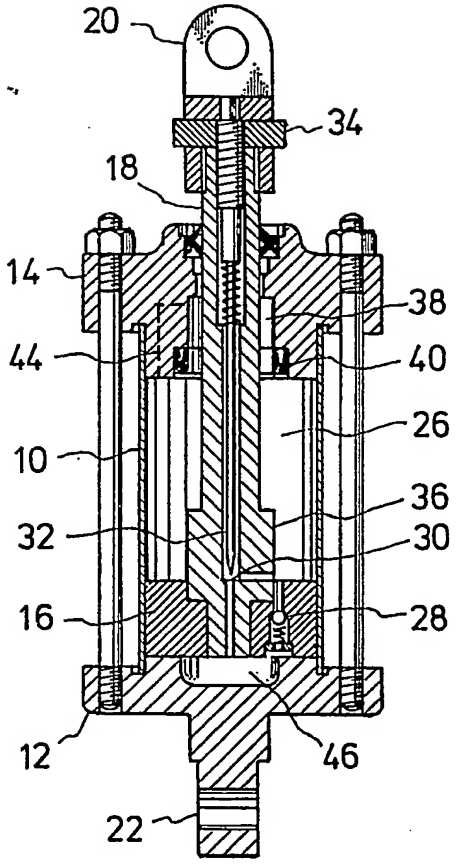

FIG. 3 (PRIOR ART)

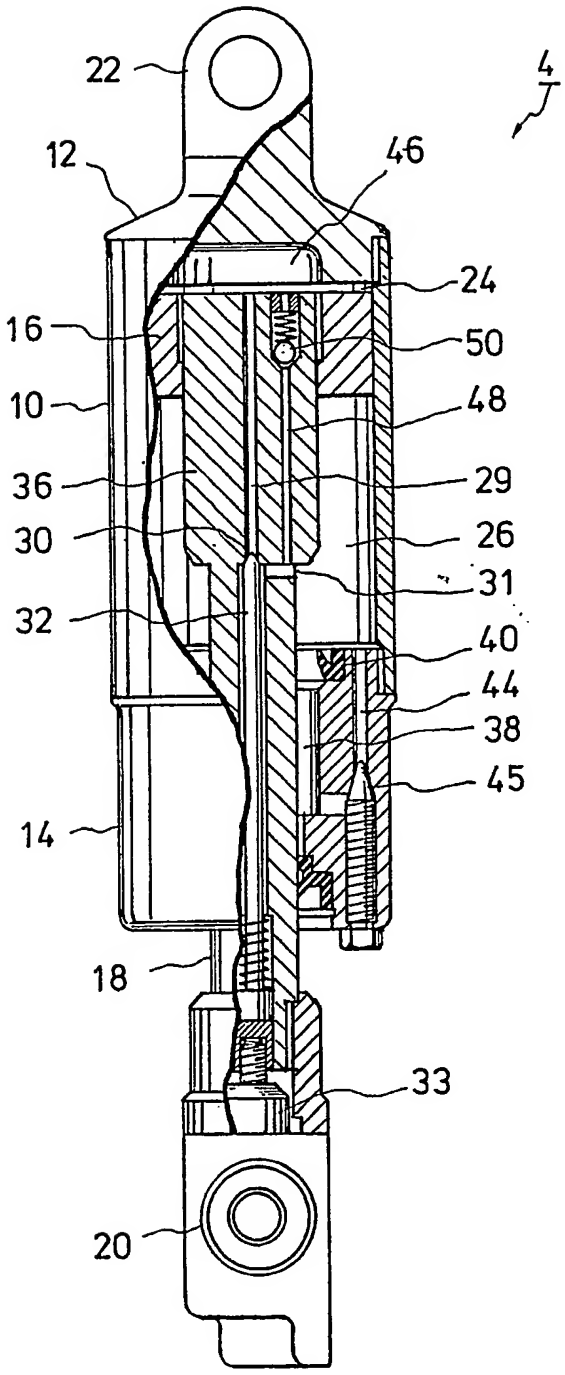

FIG. 5

CYLINDER FOR ARTIFICIAL LEG

This invention relates to a cylinder used in an artificial leg for a person having no knee joint. Typical examples of this type of artificial leg and cylinder used therein are disclosed in the Japanese patent publication No. S52-47638 and the description of prior art will be made below in connection with these examples.

As shown in Fig. 1, an artificial leg has upper and lower members 1 and 2 pivotably coupled through a joint 3 and a cylinder 4 is located between pivots 5 and 6 to support the joint of both members 1 and 2. The cylinder 4 acts with the bending of the joint caused by a walking action and serves to suitably brake and buffer the motion of the joint with its internal air pressure.

As shown in Figs. 2 and 3, the prior art cylinder comprises a cylindrical sleeve 10 having both ends closed with a head cover 12 and a rod cover 14, and a piston 16 fixed to a piston rod 18 passing through the rod cover 14 and fit slidably in the sleeve 10. The rod 18 has a coupling 20 to be coupled to the pivot 5 of the upper member 1 at an end thereof and the head cover 12 has a coupling 22 to be coupled to the pivot 6 of the lower member 2. The cylinder 4 may be inverted to couple the coupling 20 to the lower member 2 and the coupling 22 to the upper member 1, if the circumstances

admit.

The piston 16 partitions the inner cavity of the sleeve 10 into a "head chamber" 24 adjacent to the head cover 12 and a "rod chamber" 26 adjacent to the rod cover 14. Fig. 2 shows the cylinder with the piston in its extended position to give the maximum volume of the head chamber 24 and Fig. 3 shows the cylinder with the piston in its retracted position to give the maximum volume of the rod chamber 26. The piston 16 has a check valve 28 for connecting the head chamber 24 with the rod chamber 26 and the check valve 28 is arranged to allow an air flow from the rod chamber 26 to the head chamber 24 but stop a backward flow. Therefore, the piston is subjected to large resistance in the retracting direction but less resistance in the extending direction and the artificial leg straightens easily but bends awkwardly. As shown, the piston rod 18 includes a throttle valve 30 having a needle valve body 32 and connecting the head chamber 24 to the rod chamber 26, and the valve body 32 is moved forward and backward by an adjusting screw 34 to change the aperture of the throttle valve 30. Therefore, the retracting resistance of the piston or the bending resistance of the joint can be adjusted by adjusting the throttle valve 30.

As shown much better in Fig. 3, the piston rod 18 is partially enlarged in its diameter adjacent to the piston 16 and this portion will be referred to as "major diameter portion" 36. The penetration hole formed in the rod cover 14 for passing the rod 18 is partly enlarged to form a cavity 38 for receiving the major diameter portion 36 and an O-ring 40 having a V-shaped cross-section is disposed in the opening thereof. As

shown in Fig. 2, the major diameter portion 36 enters the cavity 38 and forms a cushioning chamber 42 in the bottom thereof when the piston is extended. Part of the air in the cushioning chamber 42 is discharged to the rod chamber 26 through a resistive path 44 which is schematically shown in a dashed line.

Referring next to Fig. 4 which schematically shows a human walking state, A1, A2, A3, A4, A5 and A6 denote head, back, hip, knee, heel and toe portions, respectively. While the drawing shows a cycle of walking after the heel portion A5 of one leg lands on the ground until it lands again thereon, which is broken down into thirteen positions, in total, B1, B2, ... B7 and C1, C2, ... C6, the period from the position B1 to B7 in which the heel or toe portion A5 or A6 touches the ground is referred to as "standing phase" B and the period from the position C1 to C6 in which both heel and toe portions A5 and A6 are apart from the ground is referred to as "idling phase" C. At the time of walking, when one leg is in the standing phase B, the other leg is in the idling phase C, and the walking is effected by repeating the standing and idling phases, alternately.

At the position B1, the upper and lower members 1 and 2 are substantially in line and the head and back portions A1 and A2 are a little behind the heel portion A5. From this position B1 to the position B4, the upper and lower members 1 and 2 rotate about the heel portion A5 as they are in line and, at about the same time as the toe portion A6 comes in contact with the ground at the position B4, all portions from the head portion A1 to the heel portion A5 are substantially

straightened into an erect state. While these portions from the head portion A1 to the heel portion A5 fall gradually forward as they are nearly in line from the erect position B4 and the position B7, the upper part of the body begins to rise about the hip A3 after about the position B7, and the upper and lower members 1 and 2 rotate as they are about the toe portion A6. Next, after the position C1, the toe portion A6 leaves the ground and the lower member 2 begins to rotate in clockwise direction about the hip A3 with respect to the upper member 1 or, in other words, begins to bend and, at the position C3, the bend reaches a maximum. In contrast, from the position C3 to C6, the lower member 2 rotates in counterclockwise direction about the hip A3 with respect to the upper member 1 and, at the position C6, it stretches into a nearly straightened state.

The cylinder 4 operates as follows during each cycle of walking as described above. During the standing phase B in which the upper and lower members 1 and 2 are nearly in line, the cylinder 4 is substantially in the extended state as shown in Fig. 2. After the position C1, however, it begins to retract and the air in the head chamber 24 flows through the throttle valve 30 into the rod chamber 26. By adjusting this air flow by the needle valve body 32, the swing-up speed of the lower member 2 can be adjusted adequately. As the maximum swing-up position C3 of the lower member 2, the piston of the cylinder 4 arrives at the retracted state as shown in Fig. 3 and the air remaining in the head chamber 24 is compressed in a depression 46 formed in the head cover 12. With a repulsive force of this compressed air, the cylinder 4 begins to move to its extended position to down-swing of the lower member 2.

Then, the air in the rod chamber 26 flows through the check valve 28 into the head chamber 24 and, therefore, the lower member 2 is smoothly swung down. Finally, at the position C6, the lower member 2 is completely straightened and the cylinder 4 is extended as shown in Fig. 2, in which the major diameter portion 36 fits in the cavity 38 to form the cushioning chamber 42. The cushioning chamber 42 serves to reduce shock when the upper end 2a of the lower member 2 butts against the lower end 1a of the upper member 1.

In the above mentioned prior art cylinder, however, the shock reducing effect of the cushioning chamber 42 is relatively small since its volume is small and the air therein is rapidly compressed. Especially, when the down-swing speed of the lower member 2 is high, the above mentioned shock cannot be absorbed completely and, therefore, the user is subjected to an unpleasant feeling due to this shock when he raises his walking speed. Even if the walking speed is relatively low, there will be the same problem when the artificial leg is long and heavy.

Accordingly, an aim of this invention is to provide an improved cylinder for artificial legs, which has a large cushioning chamber for completely absorbing the above mentioned shock to enable comfortable walking regardless of the walking speed and the weight of the lower member.

According to the present invention there is provided a cylinder for an artificial leg including upper and lower members pivotably coupled with each other the and arranged for the cylinder to be connected therebetween for providing suitable resistance to bending and unbending motions of said leg, comprising

a cylindrical sleeve having the ends thereof closed by a rod cover and a head cover,

a piston fixed to an end of a piston rod penetrating through said rod cover, the piston being slidable in said sleeve and dividing the interior of said sleeve into a rod chamber adjacent to said rod cover and a head chamber adjacent to said head cover, and the piston rod having a major diameter portion between said piston and a remaining minor diameter portion thereof,

a cylindrical cavity in said rod cover for receiving said major diameter portion therein,

a first flow path provided in said rod cover for connecting said cavity with said rod chamber, said first flow path including an adjustable first throttle valve,

second and third flow paths in said piston rod for connecting said head chamber with said rod chamber,

an adjustable second throttle valve disposed in said second path,

a check valve disposed in said third path to allow flow toward said head chamber,

said second and third paths being open to said rod chamber at a position on said minor diameter portion of said piston rod adjacent to said major diameter portion.

When the cylinder with this structure retracts, the air in the rod chamber 26 flows through the check valve in the major diameter portion 36 into the head chamber 24 before the major diameter portion 36 arrives at the rod cover 14. However, after the major diameter portion 36 fits in the cavity 38 in the rod cover 14, the rod chamber 26 is completely isolated

excepting the resistive path 44 to form a large cushioning chamber with itself, which can completely absorb any shock.

These and other features and operation of this invention will be described in more detail below about an embodiment thereof with reference to the accompanying drawings.

In the drawings:

Fig. 1 is a schematic diagram showing an artificial leg in which the inventive cylinder is to be used;

Fig. 2 is a longitudinal sectional view showing the extended state of the prior art cylinder which is the starting point of this invention;

Fig. 3 is a longitudinal sectional view showing the retracted state of the cylinder of Fig. 2;

Fig. 4 is a schematic diagram illustrating a walking motion of a man; and

Fig. 5 is a partial longitudinal sectional view showing the retracted state of the cylinder according to this invention.

Throughout the drawings, same reference numerals or symbols are given to the same or corresponding structural components.

Referring to Fig. 5, as in the prior art, the cylinder 4 includes a cylindrical sleeve 10 having both ends closed with a head cover 12 and a rod cover 14, and a piston 16 fixed at an end of a piston rod 18 which penetrates through the rod cover 14 and slidably fits in the sleeve 10. The piston 16 partitions the inner cavity of the sleeve 10 into a head chamber 24 and a rod chamber 26 and the piston rod 18 has a major

diameter portion 36 adjacent to the piston 16. The rod cover 14 has a cavity 38 for receiving the major diameter portion 36 therein and an O-ring 40 of V-shaped cross-section is disposed in the opening of the cavity 38. The rod cover 14 also has a path 44 bored therein for connecting the cavity 38 with the rod chamber 26 and a throttle valve 45 whose aperture can be adjusted externally is disposed in the path 44. The head cover 12 has a depression 46.

The major diameter portion 36 of the piston rod 18 has a path 29 bored therein for connecting the head chamber 24 with the rod chamber 26 and a throttle valve 30 having a needle valve body 32 is disposed in the path 29. In contrast to the prior art cylinder, the path 29 does not open at the side wall of the major diameter portion 36 but has an opening 31 in the minor diameter portion adjacent to the major diameter portion 36 as shown. The aperture of the throttle valve 30 is controlled by a motor 33 coupled to the other end of the needle valve body 32 and controlled by an electronic computer (not shown).

The major diameter portion 36 of the piston rod 18 has a second path 48 bored therein for connecting the head chamber 24 with the rod chamber 26 and a check valve 50 openable toward the head chamber 24 is disposed in the path 48. The path 48 has the opening 31 common to the path 29 in the rod chamber 26.

When the cylinder 4 extends from the position as shown, the air in the rod chamber 26 flows mainly through the path 48 and check valve 50 into the head chamber 24 and the extending motion is easily advanced. Therefore, the swing-down motion of the lower member 2 after the position C3 of Fig. 4 is effected easily. When the major diameter portion 36 enters the cavity 38

in the vicinity of the position C5, however, the path 48 is shut off from the rod chamber 26 and connected to the cavity 38 instead. Therefore, the air flow from the rod chamber 26 to the head chamber 24 has no way other than passing the path 44 having the throttle valve 45 and the cavity 38 though the air in the cavity 38 easily flows through the check valve 50 to the head chamber 24. Accordingly, this air flow is subjected to the resistance of the throttle valve 45 and the extending motion is braked. Moreover, since the remaining volume of the rod chamber 26 is large enough, the braking action is relatively slow and the shock is absorbed sufficiently. This shock absorption can be freely adjusted by adjusting the throttle valve 45 in accordance with the weight of the artificial leg and also controlled by controlling the throttle valve 30. Therefore, it becomes possible to absorb the shock in conformity with the walking speed, if the walking speed is sensed and input to the computer for controlling the motor 33. Furthermore, if the motor 33 is controlled to close the throttle valve 30 at this extended position of the cylinder, the air pressure in the head chamber 24 is sufficient for holding the upper and lower members 1 and 2 in a nearly straightened state during the standing phase B from the position B1 to B7.

When the cylinder 4 then retracts, the air in the head chamber 24 is compressed and part thereof flows in the cavity 38 through the throttle valve 30 since the check valve 50 is closed. Then, the air flowing into the cavity 38 pushes aside the inner periphery of the V-shaped O-ring 40 and flows into the rod chamber, since the volumetric change of the rod chamber 26 is much greater than that of the cavity 38. After the major diameter portion 36 of the rod 18 comes out of the

cavity 38, the air flow passing the throttle valve 30 flows directly into the rod chamber 26. If the computer for the motor 33 is preset to open the throttle valve 30 in the retraction of the cylinder, the bending motion of the lower member 2 after the position C1 is effected easily and naturally.

It should be noted that the above description is for illustrative purposes only and does not mean any limitation of the invention. It is obvious to those skilled in the art that various variations and modifications can be made on the above embodiment within the scope of this invention as defined in the appended claims. For example, the needle valve body 32 may be adjusted manually as shown in Figs. 2 and 3 instead of using the motor 33.

CLAIMS:-

1. A cylinder for an artificial leg including upper and lower members pivotably coupled with each the and arranged for the cylinder to be connected therebetween for providing suitable resistance to bending and unbending motions of said leg, comprising

a cylindrical sleeve having the ends thereof closed by a rod cover and a head cover,

a piston fixed to an end of a piston rod penetrating through said rod cover, the piston being slidable in said sleeve and dividing the interior of said sleeve into a rod chamber adjacent to said rod cover and a head chamber adjacent to said head cover, and the piston rod having a major diameter portion between said piston and a remaining minor diameter portion thereof,

a cylindrical cavity in said rod cover for receiving said major diameter portion therein,

a first flow path provided in said rod cover for connecting said cavity with said rod chamber, said first flow path including an adjustable first throttle valve, second and third flow paths in said piston rod for connecting said head chamber with said rod chamber,

an adjustable second throttle valve disposed in said second path,

a check valve disposed in said third path to allow flow toward said head chamber, said second and third paths being open to said rod chamber at a position on said minor diameter portion of said piston rod adjacent to said major diameter portion.

2. A cylinder as claimed in claim 1, wherein said

major diameter portion fits loosely in said cylindrical cavity, said cavity having an O-ring at its opening for contacting said major diameter portion and arranged to allow an air flow from said cavity to said rod chamber but to stop any backward air flow when said major diameter portion enters said cavity.

3. A cylinder as claimed in claim 1 or 2, wherein said second throttle valve is adjusted by a motor controlled by an electronic computer.

4. A cylinder for use with an artificial leg substantially as herein described with reference to Figures 1, 4 and 5 of the accompanying drawings.

5. An artificial leg including a cylinder as defined in any one of claims 1 to 4.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

GB 9301140.1

Relevant Technical fields

(i) UK Cl (Edition L) F2S - SBD WITH S102, SBF WITH S102
A5R (RFA)

(ii) Int Cl (Edition 5) F16F-9/00,9/02,9/48
A61F 2/08;2/60;2/68;2/74

Search Examiner

B F BAXTER

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search

17 MAY 1993

Documents considered relevant following a search in respect of claims 1-5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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